

ORBITAL PHLEBOGRAPHY

A method for examination of the intraorbital veins and the basal
sinuses of the skull. Technique and normal anatomy.

by

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- I BRISMAR J.: Orbital phlebography I. Technique.
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- III BRISMAR J.: Orbital phlebography III. Topography of intraorbital veins.
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- IV BRISMAR J.: Orbital phlebography IV. The cavernous sinuses and adjacent venous sinuses of the skull base.
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Reference to these papers will be made by the numerals I—IV.

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INTRODUCTION

Several intraorbital disorders are primarily venous—i.e. intraorbital venous malformations and intraorbital venous thrombosis. Furthermore, as the superior ophthalmic vein has a more constant course than the ophthalmic artery (VIGNAUD et coll 1972) a possible displacement should be detectable earlier on the venous side. The basal venous sinuses of the skull are more closely related to the base of the skull than the arteries and are therefore more prone to be affected in disorders in this region. Some disorders, like cavernous sinus thrombosis, may also directly involve these sinuses. A diagnostic demonstration of the intraorbital veins and of the basal venous sinuses of the skull is rarely achieved through arteriographic examination. There is thus a definite need for phlebographic examination. As early as 1951, DEJEAN & BOUDET demonstrated that an injection of contrast medium in the angular vein could be used to fill the intraorbital veins. BREGEAT et coll. (1952) reported that the cavernous sinus could also be filled by the same technique. However, the technique of angular vein puncture was complicated and in most cases included a surgical exposure of the vein. Therefore alternative techniques were developed (e.g. YAŞARGIL 1957, VRITSIOS 1961, BROVKINA 1964, HANAFEE et coll. 1965, PISCOL 1970, VIGNAUD 1970, TAKAHASHI & TANAKA 1971). In spite of this, the examination has not gained widespread use and it has in fact been employed as a routine method only by a limited number of investigators.

In the published reports, interest has been focused on the appearance of the superior ophthalmic veins and the cavernous sinuses in different disorders, while other intraorbital veins and basal sinuses have gained less interest. Furthermore, little information is available concerning the normal range of variation in the course and diameter of the superior ophthalmic vein as well as in the appearance of the cavernous sinus. Detailed information is thus necessary for differentiation between minor obscure lesions and normal variations.

In order to establish firm basic knowledge for the routine use of phlebographic examinations in the diagnosis of intraorbital lesions and disorders at the base of the skull, the aim of this investigation has been:

1. To develop the technique of frontal phlebography into a simple routine procedure that can be successfully performed without special equipment (I).
2. To assess the normal variations in the appearance of the superior ophthalmic vein (II).
3. To evaluate the normal phlebographic anatomy of other intraorbital veins in order to use this as a basis for refinement of the diagnosis of intraorbital expanding lesions (III).

4. To explore the normal phlebographic anatomy of the cavernous sinuses and the adjacent basal venous sinuses of the skull (IV).

Material

This investigation is based on the first 101 orbital phlebographies (in 94 patients) performed in the department of diagnostic radiology, University Hospital, Lund, Sweden,

All patients were examined because of clinical signs possibly related to one or both orbits or to the basal venous sinuses of the skull. In some cases, however, this clinical suspicion was later eliminated or the signs were explained by a disorder which could not conceivably affect these venous channels. However, the normal material thus remaining was limited and could, for ethical reasons, not be increased by adding examinations of patients without symptoms. In order to obtain a normal material for this investigation another method had to be used. Thus the following assumptions were made:

1. A unilateral intraorbital disorder (e.g. a tumor) should not affect the veins of the contralateral orbit.
2. A disorder in, or close to, the base of the skull could impair the drainage of the orbits and thus affect the diameter of the intraorbital veins, although it does not occlude the cavernous sinus. It should not, however, alter the arrangement and course of the intraorbital veins.
3. An intraorbital disorder should not affect the phlebographic anatomy of the basal sinuses of the skull when it does not occlude the intraorbital veins.

In order to study the phlebographic anatomy of the superior ophthalmic vein (II) and other intraorbital veins (III), the material was split down into *orbits* and all orbits adequately examined and without clinical suspicion of disorder were used ($n=62$). These orbits were then analyzed separately in two groups, according to whether or not there was any suspicion of a disorder affecting the basal sinuses of the skull ($n=20$ and 42 resp.). When studying the phlebographic anatomy of the basal sinuses of the skull (IV), all patients adequately examined and without clinical suspicion of a disorder affecting these sinuses were used, provided the intraorbital veins were not occluded ($n=26$).

Method (I)

Two principally different methods can be used to examine the intraorbital veins and the basal sinuses of the skull: the anterior approach via the facial veins, and the posterior approach via the inferior petrosal sinuses. For each approach different techniques have been suggested:

Anterior approach:

Surgical exposure of the angular vein (DEJEAN & BOUDET 1951). Percutaneous puncture of the angular vein (YAŞARGIL 1957). Catheterization of the angular vein from the anterior facial vein (BROVKINA 1964).

Percutaneous puncture of a frontal vein — needle (YAŞARGIL 1957, VRITSIOS 1961).

Percutaneous puncture of a frontal vein — teflon cannula (VIGNAUD 1970). Frontal vein catheterization *a.m.* SELDINGER (PISCOL 1970).

Posterior approach:

Phlebography of the internal jugular vein (GEJROF & LINDBOM 1960). Inferior petrosal sinus catheterization after puncture of the internal jugular vein (HANAFEE *et coll.* 1965).

Inferior petrosal sinus catheterization via the femoral vein (TAKAHASHI & TANAKA 1971).

The ideal phlebographic method should meet the following demands:

1. A complete bilateral demonstration of the orbital veins and the basal sinuses of the skull should always be obtained in the normal patient.
2. It should not carry risk of any serious complications.
3. It should be technically simple enough to use in every radiological department.
4. It should be possible to perform on an out-patient basis.

As the frontal vein-puncture technique permits a bilateral demonstration of the intraorbital veins, and as no serious complications have been reported in association with this technique, it was used in the present investigation. Teflon cannula had earlier been used by the author for phlebographic examinations (BRISMAR & GÖTHLIN 1972), when they proved superior to scalp vein needles (GÖTHLIN 1972) and were therefore also used in this investigation.

For puncture of a frontal vein the patient was placed with hanging head in the supine position on the examination table used for cerebral angiography.

First one a.p. series was exposed in order to check the position of the cannula and to study the anatomy of the facial veins.

A tourniquet was then placed round the forehead of the patient in order to compress the forehead veins cephalad to the injection site and the patient was instructed to digitally compress his anterior facial veins and possibly also his supraorbital veins. Information gained from the first series often proved useful in deciding how the compression should be applied. During compression short film series were then exposed in an a.p. view, a semiaxial, an axial, a straight

lateral, and, finally, an oblique lateral view with one orbit projected above the other in order to separate the veins of the two orbits. For all series 10 ml of contrast medium (Isopaque Cerebral, Nyegaard, Norway), was injected manually in about one second. One film was exposed before the injection and 4 films at one-second intervals during and after the injection.

During the latter part of this investigation, the cavernous sinuses were in several cases also examined by use of angiotomography in an a.p. view (IV).

All measurements have been made directly on the films, and no corrections have been made for the geometric magnification. The film focus distance has been 90 cm for the lateral view and 100 cm for the frontal and axial views. The patient's head has in all projections been in direct contact with the automatic film changer (AOT or PUCK, Siemens-Elema, Sweden).

Methodological Discussion

The technique used in this investigation has proved to be simple and effective and it should in all normal cases permit a good bilateral demonstration of not only the superior ophthalmic veins (II) but also of minor intraorbital veins (III) and of the cavernous sinuses with their draining veins (IV).

No complications have been encountered during this series.

The last two films in each view rarely added any extra information, and should therefore be eliminated in order to decrease the radiation dose. The series exposed before compression should for the same reason be reduced to a single exposure.

The use of a magnification technique has been advocated by WENDE & NAKAYAMA (1973). The diagnosis of an intraorbital disorder is, however, rarely based on minor pathologic venous structure. As the magnification technique would increase considerably the radiation dose on the lens, a routine use of that technique does not seem warranted although it may give valuable information in selected cases.

Photographic subtraction has been used as a routine in this investigation and has proved valuable, especially for evaluation of the basal sinuses of the skull. However, even without subtraction and without an automatic film changer, valuable information concerning the intraorbital veins can be gained. In such circumstances, a single film should be exposed immediately after the injection of contrast medium is completed.

Superior ophthalmic vein and its tributaries (II)

The phlebographic diagnosis of intraorbital disorder has been based largely upon the appearance of the superior ophthalmic vein. The frontal-vein approach

permits a comparison between the two orbits and thus even minor asymmetries in the course and diameter of the vein can be disclosed. The aim of this paper was to study to what degree such asymmetries may be due to normal anatomic variations and to variations in technique.

The normal anatomy of the superior ophthalmic vein has been well known for a long time (e.g. SESEMAN 1869), and the previous descriptions were confirmed in this investigation. The superior ophthalmic vein is formed behind the pulley of the superior oblique muscle by the union of tributaries from the supraorbital and angular veins. At first it courses backwards but soon turns laterally to enter the muscular cone. It crosses under the superior rectus muscle, appears again on the lateral side of that muscle and then runs backwards close to the orbital roof. In the posterior part of the orbit, the vein descends to leave the orbit through the superior orbital fissure and empty into the cavernous sinus. The constancy of the double origin of the superior ophthalmic vein, demonstrated in this report, has been overlooked by most earlier investigators (e.g. BOUDET 1953, LOMBARDI & PASSERINI 1968, SCHÖBER & BENDER 1968). In the present series, in five patients out of 17 without any suspicion of an intraorbital disorder, significant intraindividual differences in the course of the superior ophthalmic vein were found. In four of these cases, thin unilateral double segments of the superior ophthalmic vein probably explained the asymmetry; in the fifth case the injection of contrast medium was directed laterally. As noted in another case, the distension of the vein achieved during compression of the facial veins, may appear as a dislocation of the vein. In several cases the superior ophthalmic vein in the a.p. view unilaterally described an extra loop anterior to its entrance into the muscular cone. The interindividual differences were still larger, and thus it does not seem meaningful to give normal measurement values for the course of the superior ophthalmic vein as was done by OFFRET & ARON-ROSA (1965).

As first noted by SESEMAN, the superior ophthalmic vein constantly narrows as it passes through the superior orbital fissure. This finding was confirmed in this study. The mean value for the maximum diameter of the intraorbital part of the superior ophthalmic vein in the lateral view was found to be 3.5 mm, while the mean value for the minimum diameter of the vein during its passage through the fissure was 1.8 mm in the lateral view and 1.2 mm in the frontal view. It is of major importance to keep in mind this constant narrowing in the posterior part of the vein in order not to mistake it for a relative hindrance at the level of the superior orbital fissure. OFFRET & ARON-ROSA stated that the diameter of the superior ophthalmic vein in normal cases should not exceed 2.0 mm. They later increased that limit to 2.5 mm (ARON-ROSA et coll. 1967). HANAFEE et coll. (1968), however, claimed that a diameter of 5 mm could

be normal, and that large differences in diameter may exist intra- as well as interindividually. In the present series the maximum diameter of the superior ophthalmic vein in 53 normal orbits, ranged from 1.8 to 5.9 mm (measured in the lateral view during compression of the facial veins). In 44 patients the effect of compression was evaluated in detail. The mean increase in diameter during compression of the facial veins, as compared to the diameter when examined before compression, amounted to 45 % (range 0—200 %). A lateralized contrast media injection will give different distension of the veins in the two orbits and may thus produce large intraindividual differences in diameter of the intraorbital veins.

As it could not, *a priori*, be excluded that a relative impediment of flow through the cavernous sinus could affect the diameter of the superior ophthalmic vein, mean values of diameters were calculated separately for patients with and without suspicion of a disorder affecting the cavernous sinuses. No significant differences were found, however, between these two groups.

It has earlier been stressed that 'lack of filling of the superior ophthalmic vein may be a purely technical result or may be related to an increased-flow phenomenon' (HANAFEE 1972). However, with the technique used in this investigation, non-filling of one of the superior ophthalmic veins is definitely pathologic provided that the injection of contrast medium is intravascular, that large enough veins connect the injection site with the orbits, and that the external compression has been effective. Whether or not these conditions have been met is evident from the films.

Topography of intraorbital veins (III)

As normally significant variations in the course of the superior ophthalmic vein may exist (II), the diagnosis of a small intraorbital expanding lesion is often hazardous. The technique used in this investigation, however, produces a contrast filling of several other intraorbital veins. Thus it was considered worthwhile to make an attempt to systematize the appearance of those veins in order to refine the diagnosis of intraorbital disorders.

In most earlier reports on orbital phlebography (e.g. BOUDET, ARON-ROSA et coll. 1967, HANAFEE 1972) little interest has been given to intraorbital veins other than the superior ophthalmic vein, and no analysis of their phlebographic appearance has been presented earlier. The inferior ophthalmic vein was filled in 37 out of 57 orbits in the normal material (65 %). In seven orbits double inferior ophthalmic veins were found. While normally the inferior ophthalmic vein is localized close to the orbital floor, the additional vein (probably corresponding to the 'veine ophtalmique moyenne' described by HENRY 1959)

had a similar course but was localized higher up in the orbit. In some cases, where only a single inferior ophthalmic vein was opacified, this had the same high location. A knowledge of this variant is important in order to avoid the false diagnosis of an inferiorly located expanding lesion in such cases.

A medial ophthalmic vein was identified in 22 out of 57 normal orbits (39 %). This vein has not been described earlier at phlebography. It has its origin in the angular tributary to, or the anterior segment of the superior ophthalmic vein and runs backwards close to the medial orbital wall. In the anterior and middle part of the orbit it is situated close to the orbital roof, but in the posterior part of the orbit it descends to enter the cavernous sinus situated below the superior ophthalmic vein. The medial ophthalmic vein is of diagnostic importance as it may be mistaken for a dislocated superior ophthalmic vein in case the latter is occluded.

Four veins connecting the superior ophthalmic vein with the lower part of the orbit or with the inferior ophthalmic vein were identified in this study. These veins were named the anterior, posterior, medial and lateral collateral veins according to their position in the orbit. The anterior collateral vein (seen in 52 out of 57 orbits, i.e. 91 %), runs along the anterior part of the medial orbital wall down to a venous rete, situated on the medial-anterior part of the orbital floor. This vein is likely to be affected in disorders in the anterior medial part of the orbit.

As the superior ophthalmic vein enters the muscular cone it gives off the medial collateral vein (opacified in 55 out of 57 orbits, i.e. 97 %). The medial collateral vein then passes on the medial side of the muscular cone and joins the rete mentioned above and sometimes also the inferior ophthalmic vein. After the superior ophthalmic vein has crossed under the superior rectus muscle and appeared on its lateral side, it gives off the lateral collateral vein. This vein, seen in 41 out of 57 orbits (72 %), then passes on the lateral side of the muscular cone downwards frontally, in most cases to the lateral-anterior part of the orbital floor, where it may anastomose with the inferior ophthalmic vein. These two collateral veins, due to their position on each side of the muscular cone, are important in the localization of an intraorbital expansivity.

The posterior collateral vein (seen in 11 out of 57 orbits, i.e. 19 %) short circuits the posterior part of the superior ophthalmic vein and passes on the lateral side of the muscular cone. This vein has a bizarre, irregular appearance in the lateral view, and may thus tempt an examiner to regard it as a pathologic collateral indicating a block at the level of the superior orbital fissure, especially as the diameter of the superior ophthalmic vein is regularly highly reduced at this level.

Cavernous sinuses and adjacent basal venous sinuses (IV)

In the present investigation it was demonstrated that provided the orbital veins are unobstructed and the technique correct, an adequate bilateral demonstration of the cavernous sinuses and adjacent basal sinuses, should always be achieved when using frontal phlebography. The final part of the study was undertaken to clarify the normal phlebographic anatomy of these venous pathways, as available information was incomplete and partly confusing. The normal material available consisted of 26 examinations in patients without any clinical suspicion of a disorder that might affect the basal veins of the skull.

Some earlier investigators of phlebography (BOUDET, BÉTOULIÈRES et coll. 1957, ARSENI et coll., OFFRET & ARON-ROSA, DEBAENE 1972) found three different types of cavernous sinuses: the single-vein type, the double- or triple-vein type, and the venous plexus type. These findings have not been confirmed in this study and were probably due to a nonoptimal technique (slow injection of contrast media with consequent layering effects). In the present series the cavernous sinus always appeared as a virtually unbroken venous channel surrounding the intracavernous part of the carotid artery. It has earlier been argued among anatomists, whether the carotid artery is located in the lateral wall of the cavernous sinus (e.g. BEDFORD 1965) or is surrounded by venous tissue (e.g. MERCIER et coll. 1970). In this material venous tissue was always seen on the lateral as well as on the medial side of the carotid artery. Thus variations in the anatomy of the intracavernous part of the carotid artery will affect the appearance of the cavernous sinus. In several cases, a tortuous carotid artery has been found to dislocate part of the cavernous sinus medially.

The cavernous sinuses are interconnected through the anterior and posterior intercavernous sinuses (seen in 21 and 18 out of 26 cases, respectively) and the basilar plexus (filled in 25 out of 26 cases). The medial parts of the cavernous sinuses form the lateral walls of the pituitary fossa while the intercavernous sinuses are connected to the anterior and the posterior sellar diaphragm, respectively. Dislocation of these sinuses, especially lateral dislocation of the cavernous sinuses, has been used as a diagnostic sign of an intrasellar expanding lesion, although no normal values for the transverse diameter of the pituitary fossa have been presented. In the present investigation this diameter (measured as the largest transverse diameter of the oval area that is outlined in the axial view by the cavernous and inter-cavernous sinuses) in adults amounted to a mean $17.8 \text{ mm} \pm 2.0 \text{ mm SD}$, measured directly from the film.

The cavernous sinuses are anteriorly connected to the ophthalmic veins and often also to the sphenoparietal sinuses (filled by contrast medium in 19 out of 26 cases). The sphenoparietal sinuses in frontal views are easily mistaken for lacrimal veins, but can be identified in the axial view.

The relative importance of different routes of drainage of the cerebral blood and the hemodynamic effects of changes in posture (e.g. DILENCE & PERCY 1973) is a matter of debate. From the present investigation, however, it appears that the drainage route from the cavernous sinus via the plexus of the foramen ovale to the pterygoid plexus may be much more important than was earlier suspected. This route was demonstrated in 24 out of 26 normal cases, while the inferior petrosal sinus was seen in 24 out of 25 cases. It often had a larger diameter, and was more densely filled than the inferior petrosal sinus. In several earlier reports on phlebography the plexus of the foramen ovale has been a matter of confusion—by some authors (MORRIS & WYLIE 1973) it has been mistaken for the inferior petrosal sinus, by others (e.g. ARON-ROSA *et coll.* 1966, 1967, VIGNAUD 1970), for the superior petrosal sinus. This latter sinus is, in fact, only rarely discernible in phlebography (2 out of 25 cases in this material—in one newborn and one infant).

General summary and conclusions

The frontal approach in orbital phlebography used by the author is presented in detail. This technique has proved effective in demonstrating the intraorbital veins and the basal sinuses of the skull.

The normal anatomy of the superior ophthalmic vein has been re-evaluated. Significant variations in the course and diameter of the superior ophthalmic vein were found to occur intra- as well as interindividually. Thus, a slight asymmetry only in the course of the superior ophthalmic vein does not warrant the diagnosis of an intraorbital expanding lesion.

The technique used in this investigation permits a constant demonstration of even minor intraorbital veins. In order to refine the diagnosis of intraorbital disorders, the phlebographic anatomy of these veins was evaluated. In addition to the superior and inferior ophthalmic veins, a medial ophthalmic vein was found in one third of the orbits. Four collateral veins were identified. The variations in course and arrangement of the intraorbital veins was described in detail.

Earlier opinions on the phlebographic anatomy of the cavernous sinuses and adjacent basal sinuses have been revised. The cavernous sinus was found to have the appearance of a virtually unbroken venous channel surrounding the carotid artery. In addition to the inferior petrosal sinus, the pterygoid plexus was found to be an important drainage route for the cavernous sinus. In order to form a basis for the use of phlebography in the diagnosis of intrasellar expanding lesions, the normal range of the transverse diameter of the pituitary fossa was determined.

As no complications have at any time been described in the literature and

none were seen in the present material and as no special post-examination attention is necessary, the technique is well suited for use on an out-patient basis.

No special equipment is needed, and thus the examination can be performed in any radiological department. It is therefore suggested that orbital phlebography should be the first special radiological procedure used (following skeletal examination) in the evaluation of intraorbital disorders that may affect the orbital veins, and that this examination should be used at an early stage in the investigation of disorders in the vicinity of the cavernous sinuses.

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